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LINEAR PERSPECTIVE

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LINEAR PERSPECTIVE,

FOR THE USE OF SCHOOLS

AND

STUDENTS IN DRAWING.

By JOSEPH ROPES.

> "Every man should be able to sketch a road or a river, to draw the outlines of a simple machine, a piece of household furniture, or a farming utensil, and to delineate the internal arrangement and construction of a house."—Horace Mann.

FOURTH EDITION. REVISED BY THE AUTHOR.

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PREFACE.

It is the author's aim, in the following treatise, to present clearly and concisely the *principles* of Perspective, without a knowledge of which the student is liable to be embarrassed by every new object which he attempts to draw. His endeavor has been to simplify what commonly appears intricate, by showing the reason for each process, and reducing the whole to two general rules, which will be found sufficient for the solution of every problem.

It is believed that the work will commend itself to those for whom it is designed, as an easy and intelligible manual of the important science of which it treats.

New York, Dec. 18, 1849.

The undersigned have examined the system of Perspective presented by Mr. Ropes, and cheerfully accord our favorable opinion, convinced that it is at once simple and practical.

Paul P. Duggan,
Vincent Colyer,
B. F. Childs,
T. A. Richards,
J. F. Cropsey,
F. E. Church,
H. B. Gay,
Alfred Jones,
J. B. Stearns,
D. W. C. Boutelle,
T. H. Matteson,
J. M. Falconer.

LINEAR PERSPECTIVE.

PART I.

Linear Perspective is the art of representing the outlines of objects on a plane surface, from a given point of view, as truly as though they were traced on a transparent medium held between them and the eye.

If, for illustration, we erect upon a table a pane of glass, and place a cubic block at a short distance from it, and, holding the eye at a fixed point before the glass, trace thereon the outlines of the block, the result will be, as in Fig. 1, a correct perspective representation of it. The side *A*, parallel to the face of the glass, will be a square. But the top, and side *B*, receding from the eye, will diminish, and the lines *d*, *e*, *f*, continued, will meet in a point *S* directly opposite to the eye, which is called their *vanishing point.*

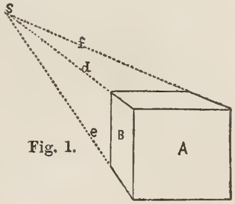


Fig. 1.

From this we may conclude that while all lines parallel to the surface of the glass, or *picture plane,* as it may be called, remain unchanged in their direction, and are to be drawn as they are in the original object, all others converge toward some point which it is the purpose of the rules of perspective to determine.

A familiar illustration is that of a long and straight street, in which the vertical lines of the buildings retain that appearance, however distant they may be; but the receding horizontal lines apparently converge until they seem almost to meet in the extreme distance.

To make a true perspective drawing, therefore, we must know how to find the vanishing point. This it is our first object to elucidate. In doing so we shall have occasion to use a few terms that need to be defined.

DEFINITIONS.

PERSPECTIVE PLANES, LINES AND POINTS.

The Picture Plane is an imaginary transparent plane between the artist and the objects he intends to draw. The seat of representation of those objects is where visual rays, in passing from them to the eye, cut the picture plane. The paper or canvas on which the drawing is to be made answers to this imaginary plane and is called by the same name.

The Ground Plane is an imaginary horizontal plane, on which the picture plane is supposed to stand upright. On it are the objects of the picture—hills, trees, buildings, etc.

The Ground Line is the base line of the picture, formed by the junction of the picture and ground planes.

The Horizon Plane is parallel to the ground plane. It passes from the eye to the horizon, cutting the picture plane at right angles. It may be represented by a sheet of tin held level with the eye, in such a way as that neither surface, but only the nearest edge, can be seen. As this edge is but a line, therefore a line on paper stands as a representative of the entire plane.

The Horizon Line, which represents the horizon plane, is always at the height of the eye above the ground plane.

The VERTICAL PLANE is perpendicular to the ground plane, and tends from the spectator indefinitely into the distance, cutting the picture plane at right angles. If a sheet of tin is held vertically, so that only the nearest edge can be seen, we have a representative of the vertical plane. This edge is but a line, and is so expressed on paper.

The PRIME VERTICAL LINE is the representative of the vertical plane.

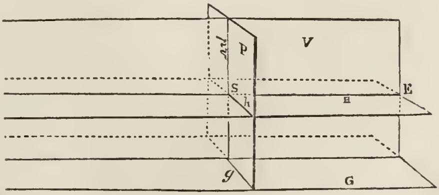
The CENTRAL VISUAL RAY is the most direct ray of light that passes from the distance to the eye. It coincides with the junction of the horizon and prime vertical planes, and is represented on the picture plane by a point called the point of sight.

The POINT OF SIGHT designates the central visual ray, and is always marked on the horizon line, at its junction with the prime vertical.

The POINT OF DISTANCE represents the distance of the artist from the picture plane. In other words, it represents the eye itself, transferred to the picture plane (for the purpose of working out the problems) by setting off the distance on the prime vertical line, measuring from the point of sight.

Figure 2 is a perspective view of the above-named planes. They are shown as transparent; the parts seen through the others being continued in dotted lines. *V*, *H*, and *G* are supposed to extend from the eye indefinitely.

Fig. 2.

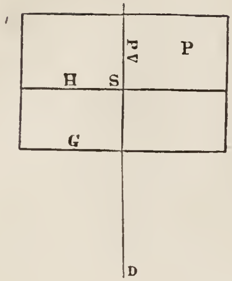


References to Fig. 2.

P. Picture Plane.
V. Vertical Plane.
H. Horizon Plane.
G. Ground Plane.
E. The Eye.
S. Point of Sight.
g. Ground Line.
h. Horizon Line.
p.v. Prime vertical line.

These three lines are formed by the intersection of the planes, and are shown again in Fig. 3, which is a front view of the picture plane.

Fig. 3.



References to Fig. 3.

P.	Picture Plane.
G.	Ground Line.
H.	Horizon Line.
P. V.	Prime Vertical Line.
S.	Point of Sight.
D.	Point of Distance.

D represents the distance of the eye from the picture plane, *i. e.*, the distance from *S* to *E* in Fig. 2. It may be set off either above or below the point of sight, on the prime vertical line, which is continued for this purpose beyond the limits of the picture.

TO PREPARE THE PICTURE PLANE FOR SKETCHING.

In preparing the picture plane, as in Fig. 3, it may be observed that as the horizon line indicates the height of the eye, it will be higher or lower according as the position of the artist is more or less elevated. Ordinarily it will be about one-third the height of his picture, but higher if he stands on high ground.

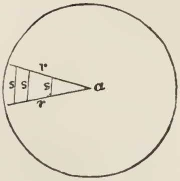
The prime vertical line will be in the middle, or on one side, according to the portion of the view which he wishes to include in his drawing.

As he views the scene, his eye takes in a certain part of the horizon, say thirty degrees, and the imaginary vertical plane divides it equally, giving fifteen degrees on each side. If he chooses to include the whole, he will draw the vertical line through the middle of the picture plane. If he wishes to leave out a portion at the left hand, the vertical line will be drawn nearer the left edge of the picture, and if at the right hand, nearer its right edge. If only half the scene is to be shown, then the vertical line, and consequently the point of sight, will be at the edge of the picture. It is as if the entire view were drawn with the vertical line and point of sight in the middle, and then a portion of the view were cut off, leaving them nearer the side.

CHOICE OF DISTANCE.

One thing more is to be considered preparatory to making a sketch, viz., the distance of the artist from the scene or object he is about to draw. This should be so arranged that he can take it in at a view without turning his head. He stands in the centre of a circle, of which the circumference is the horizon. The circle measures 360 degrees, of which only from 30 to 45 degrees can conveniently be seen. Suppose his field of view to be the former, viz., 30 degrees, or what is included between the radii *r*, *r*, Fig. 4. Then, as the radius is equal to one-sixth of the circumference, *i. e.*, 60 degrees, it follows that he will be removed from the scene he is sketching twice its width; for at whatever points the lines *s*, *s* are drawn, it will be twice their length thence to his position at *a*.

Fig. 4.



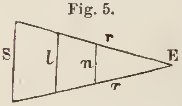
To apply this principle, determine as nearly as possible what objects are to come into the picture at its lower corners; imagine a line, answering to the ground line, *s* Fig. 4, drawn from one to the other, and then choose a position twice the length of that line away from it, as at *a*.

If more than 30 degrees are to be included, the distance of the position will be less in proportion to the width of the picture, and if less than 30 degrees it will be more.

This distance being determined, it must be set off on the prime vertical line as in Fig. 3.

To render this point still plainer, let us note the relation between the original ground line and picture plane, and their representatives. The original ground line is the lowest boundary of the scene to be sketched, passing horizontally between the objects that have been selected to terminate the picture at its lower corners. The original picture plane is supposed to stand upright on this ground line, wide and high enough to include the whole scene. Suppose this ground line to be 50 feet long, and the artist to stand 100 feet from it in sketching. His representative picture plane is a sheet of paper, on which he has drawn a ground line, say six inches in length. This length answers to the original 50 feet. He will therefore double it for his point of distance, and set off 12 inches on the prime vertical line as before directed. The images of all objects, as they pass from the original picture plane to the eye, are reduced in the same ratio as the plane itself. This is illustrated by Fig. 5. Let *S* be the original picture plane, and *l* or *n* its representative. It is evident that all which is contained within the limits of the plane at *S*, must pass through the smaller planes *l* and *n*, in a diminished form, to reach the eye at *E*.

Fig. 5.



TO DETERMINE VANISHING POINTS.

We are now prepared to consider the vanishing points of lines. Keeping in mind the series of planes, Figure 2, we remark first that all planes and lines which are parallel to the picture plane are easily disposed of, since, as seen in Figure 1, they do not vanish. Their *dimensions*, as they are more or less distant, are affected by the laws of perspective, but their *direction*, whatever it may be, is unchanged.

The next fact to be noted is, that all planes parallel to the horizon plane vanish in the horizon, and all planes parallel to the prime vertical plane vanish in the prime vertical. This may be familiarly illustrated. If we stand on the sea-shore when the water is calm, we see in its surface an immense plane, which though horizontal, appears to rise as it recedes, until it vanishes at the height of the eye in the horizon, *i. e.*, in our horizon plane. If we ascend a hill and look in the same direction, we find that the horizon has ascended with us, and is still the vanishing line of the sea. So it is with lesser planes, as the floor of a room, seats of chairs, the tops of tables, etc.; if they are parallel to the horizon plane, they vanish in it. If they are below the eye, they appear to rise, and if above it, to descend toward their vanishing plane.

It is similar with upright planes, as the sides of a room or street. If they are parallel to the vertical plane, those on the left appear to tend to the right, and those on the right to the left, until they vanish in the prime vertical plane. As we look down a long room, this convergence of the two sides toward the prime vertical, and also of the floor and ceiling toward the horizon is very apparent, and it is quite clear that if continued it would terminate in a point opposite the eye, or the point of sight.

Now, all planes may be supposed to be made up of lines, which will of course vanish with the planes to which they belong. If, for example, the surface of the sea were covered with lines, intersecting each other in all possible directions, each of those lines, excepting such as are parallel to the picture plane, would have its vanishing point somewhere in the horizon plane; and if the sides of a room parallel to the P. V. Plane were in the same way intersected by lines, each would vanish somewhere in that plane. Precisely where these several lines would vanish—whether at the point of sight, or to the right or left of it on the horizon, or above or below it on the prime vertical—must depend on their direction. Only those which are at right angles to the picture plane, and consequently are parallel to the central visual ray, vanish in that ray, *i. e.*, in the point of sight, inasmuch as such only are parallel to both the horizon and prime vertical planes, and therefore necessarily vanish in both at their point of intersection.

Having shown that planes vanish in parallel planes, we may now announce the rule for vanishing lines, viz., that they also vanish in their parallels.

RULE I.

ALL LINES VANISH IN AN IMAGINARY LINE FROM THE EYE, TO WHICH THEY ARE PARALLEL.

In conformity with this rule, as before demonstrated, all lines in nature, or in whatever object, which form a right angle with the picture plane, vanish at the point of sight, which is the representative of a line from the eye (the central visual ray) parallel to such lines. In the degree, and according to the direction in which vanishing lines vary from this angle, will their vanishing points be removed from the point of sight; the distance and direction being always determined by a line from the eye parallel to them. This principle should be well established in the mind, and the rule committed to memory. Its practical application will appear as we proceed.

There are but nine distinct relations which a vanishing line can hold to the picture plane.

First—parallel to the central visual ray.

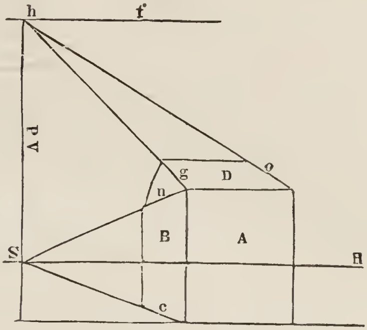
Second and third—parallel to the prime vertical, but not to the horizon planes, its direction being either upward or downward as it recedes.

Fourth and fifth—parallel to the horizon plane, and not to the prime vertical, but tending either to the right or left.

The remaining four positions are those of lines which are not parallel either to the horizon or vertical planes, but which in receding from the picture plane, tend either, 1st, upward and to the left; 2d, downward and to the left; 3d, upward and to the right; 4th, downward and to the right.

Two simple illustrations will suffice to give a general idea of these various relations, and the way in which they affect the vanishing point. Fig. 6 is a house, one side of which, *A*, is parallel to the picture plane. The ground plane on which it stands vanishes in the horizon plane, *H*, and the side *B*, in the prime vertical plane, *P. V.*, to which it is parallel. The line *c* is common to both *B* and the ground planes, and consequently vanishes at the point of sight, *S*, as also *n*, which is parallel to *c*, and both these lines fall under what we have designated as the first relation.

Fig. 6.



The side of the roof, *D*, is an ascending plane, and vanishes above the horizon in a line *f*, which is the representative of a plane parallel to *D*, extending from the eye, and cutting the picture plane at that line.*

The line *g* is common to *B* and *D*, and therefore vanishes with both planes in *P. V.*, and *f*, at *h*. *o* being parallel to it, vanishes at the same point. The reverse line of the roof from *g* is descending, and as its angle of inclination to the picture plane is the same as *g*, it vanishes in *P. V.* below the horizon, as far as *g* does above it. These lines are instances of the second and third relations.

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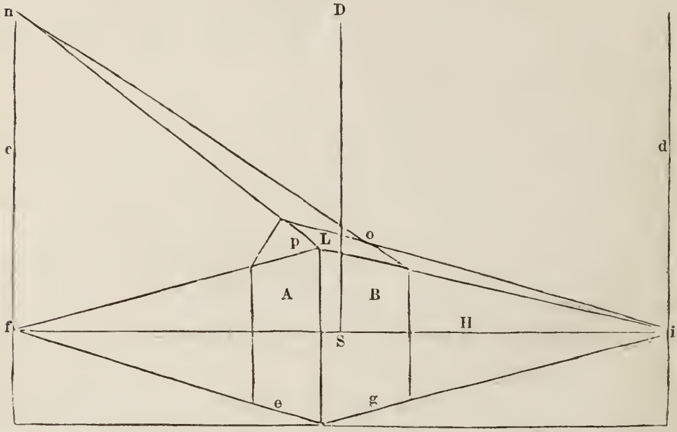
* These lines usually fall outside the bounds of the picture. When, therefore, we speak of the intersection of the picture plane, it is supposed to be extended. A large sheet of paper may be called the plane of the picture, although the picture upon it may not occupy an inch.

Figure 7 is a house seen cornerwise. Instances of the fourth and fifth relations of a line to the picture plane are found in *e* and *g*. Neither *A* nor *B* is parallel to the prime vertical plane, but *A* inclines to the left and vanishes in *c*, which represents a plane from the eye parallel to *A*, and *B* in like manner inclines to the right and vanishes in its parallel plane *d*. Since *e* and *g* belong to the ground plane, they vanish in the horizon, but as they belong also respectively to the sides *A* and *B*, they vanish in *c* and *d*, consequently at *f* and *i*.

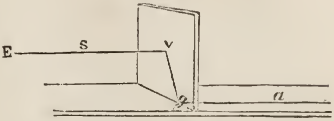
Fig. 7.



In the lines of the roof we have an illustration of the remaining relations. Thus *L*, an ascending plane, vanishes above the horizon, and *p*, because it is common to *A* and *L*, vanishes to the left of the prime vertical in *c* at *n*. Its parallel *o* of the roof vanishes at the same point. The descending line of the roof likewise vanishes in *c*, but as far below the horizon as *n* is above it.

The truth of the rule we have given for determining vanishing points may be clearly demonstrated. Set up a pane of glass on a table, Fig. 8. Draw on the table a line *a*, at right angles with the face of the glass. Carry a string *s*, from the eye *E*, parallel with *a*, until it cuts the picture plane at *v*. This line answers to the central visual ray, and *v* is the point of sight. Now, with the eye fixed at *E*, trace the appearance of *a* on the glass. Its representative *g* will be found to run toward *v*, showing that to be its vanishing point. It must be understood that in all cases where this point is marked on the picture plane, it stands for the *real vanishing point* in the extreme distance.

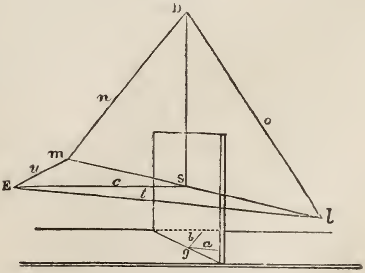
Fig. 8.



Vary now the position of *a* on the table, so that it will incline to the left as it recedes from the glass, and, with the eye still at *E*, trace again its appearance. It will be found to vanish on the horizon to the left of *v*, and if you stretch a line from *E* to its vanishing point, this line will be precisely parallel to the line *a* in its new position on the table.

To show the application of our rule in determining *definitely* the vanishing points of such lines as do not vanish in the point of sight, we will use another illustration, Fig. 9. Draw two lines *b a* on the table, both oblique to the picture plane. These are lines whose vanishing points are to be ascertained. *E* is the eye, *c* the central visual ray, *S* the point of sight;

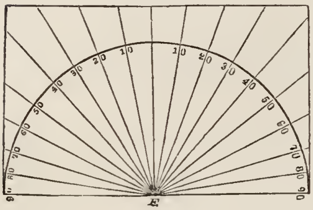
Fig. 9.



t is a line parallel to *a*, and *u* parallel to *b*.[*] Whatever angle *a* and *b* form with the picture plane at *g*, will consequently be repeated at *E*. Take now the distance from *S* to *E*, and set it off at *D*. *D* is the point of distance, and, as before explained, represents the eye itself transferred to the picture plane. Draw *n* and *o*, forming the same angle at *D* as *u* and *t* at *E*, and where they cut the horizon, as at *l* and *m*, are the vanishing points.

As a practical aid in applying the rule, draw on a thick card a semicircle, and divide it into degrees, as in Fig. 10. *E* represents the eye. Hold the card horizontally, so that the middle line will coincide with the central visual ray (*c*, Fig. 9). Then place on the card a pencil or ruler parallel to the line of which you wish to find the vanishing point. Note what angle it forms with the central ray, and you will then know how many degrees to the right or left of the point of sight is the vanishing point. Make the same angle with the *P. V.* line at *D*, and where this line continued cuts the horizon, is the point required.

Fig. 10.



If the object to be drawn is rectangular, it will be necessary to find the vanishing point of only one side by the card, the other angle being the complement of that already found. Thus, if it appears that one side vanishes at 30 degrees to the left of the prime vertical, the other will vanish 60 degrees to the right.

Having now established the rule for ascertaining vanishing points, we shall proceed to consider the method of determining perspective distances, which is simply that of finding a point on a vanishing line.

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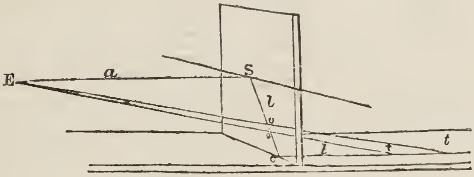
[*] As this diagram is in perspective, lines originally parallel are not so here.

PERSPECTIVE DISTANCES.

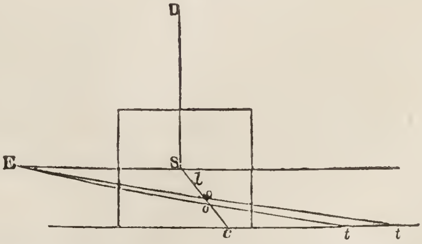
To obtain a rule for determining perspective distances, let us first see *what* is to be done, as exhibited in Fig. 11. *E* is the eye. *a* the central visual ray. *S* the point of sight. *b* is a line parallel to the central visual ray, and therefore represented on the picture plane by *l*, which vanishes at *S*. *t, t* are points on *b* whose precise place on the picture plane is to be found. It is evident that their representatives will be somewhere on *l*, where rays from *t, t* to the eye intersect it—viz., at *o*, *o*.

Fig. 11.



To reduce this to a flat surface, both *E* and the points *t, t* must be transferred to the picture plane. On *S*, as a centre, turn the line *a* horizontally into the picture plane, and on *c*, as a centre, do the same with the line *b*. In other words, take the distance of the eye from the vanishing point, and set it off on the horizon line from *S*, and also the distance of *t, t* from the picture plane, and set it from *c* on the ground line. The result will be as in Fig. 12, which is a front view of Fig. 11. Lines from *t, t* to *E* represent rays of light from the original points to the eye, and cut the vanishing line *l*, as before, at *o*, *o*.

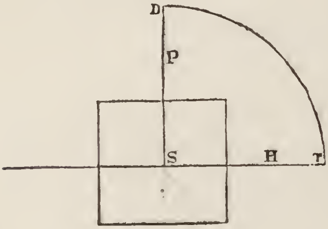
Fig. 12.



The distance of the eye from the vanishing point, when set off on the horizon for the purpose just indicated, is called, by way of distinction, the *radial point.* It is found by placing one foot of the dividers at the vanishing point, and the other at the point of distance, and setting off this measurement on the horizon from the vanishing point.

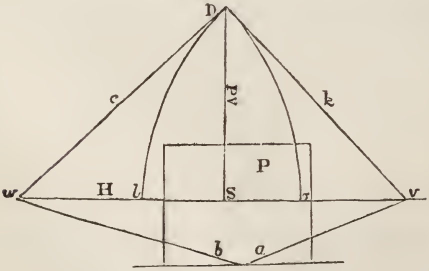
Figure 13 is the picture plane prepared for parallel perspective. *S* is the point of sight, and in this case the vanishing point; *D* the point of distance, *H* the horizon, *r* the radial point, obtained by making *S, r* equal to *S, D.* Both *D* and *r* stand on the picture plane for the eye. Suppose the eye in front of the picture plane, connected with *S* by a thread. If it turns on *S* as a centre, horizontally, it falls at *r;* if vertically, at *D.* The radial point may be set off on either side of *S* as occasion requires.

Fig. 13.



In oblique perspective there are many vanishing points, and each has its own radial point, as illustrated by Fig. 14, where *v* and *w* are vanishing points for the oblique lines *a* and *b.* To obtain their radial points, place one foot of the dividers at *w* and the other at *D,* and set off the distance on the horizon from *w* to *r,* which gives the radial point to be used in determining distances on the vanishing line *b.* Again, place the dividers from *v* to *D* and draw to *l,* which is the radial

Fig. 14.



point for the vanishing line *a*. Thus it will be seen that each vanishing line has its own radial point, which is to be used in finding required points on that line. From these statements and illustrations we deduce the following rule.

RULE II.

FROM THE POINT OF JUNCTION OF THE VANISHING AND GROUND LINES, SET OFF ON THE LATTER, BY SCALE OR PROPORTION, THE DISTANCE REQUIRED, AND RULE THENCE TO THE RADIAL POINT, AND WHERE THIS LINE CUTS THE VANISHING LINE IS THE PERSPECTIVE OF THAT DISTANCE.

The application of this rule may be seen in Figures 15 and 16. Fig. 15 is a block whose vanishing sides are at right angles with the picture plane. *t* and *l* vanish at the point of sight, and the radial point is found as in Fig. 13. It is required to make the side *A* equal to *B*. Therefore, set off the width *g e* from *e* to *c*, and rule to *r*. The intersection of this line with *l* at *p* determines the width of *A*.

Fig. 15.

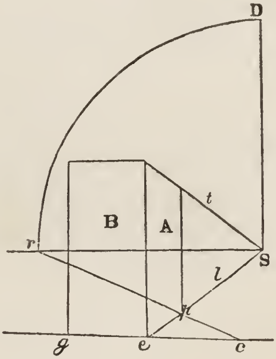


Fig. 16 is a block in oblique perspective, the height of which is twice the width of its sides, *B*, *A*. *v* and *r* are its vanishing points; *o* and *n* their radial points, obtained as in Fig. 14. Draw the corner line, *t*, and the vanishing lines *a*, *b*, *e*, *f*. For the width, set off half the height of the line, *t*, on the ground line from *c* to *l*, and from *c* to *m*. Rule from *m* to *o*, and *l* to *n*, and where the one line cuts *b*, and the other *a*, are the points which determine the perspective width of *A* and *B*.

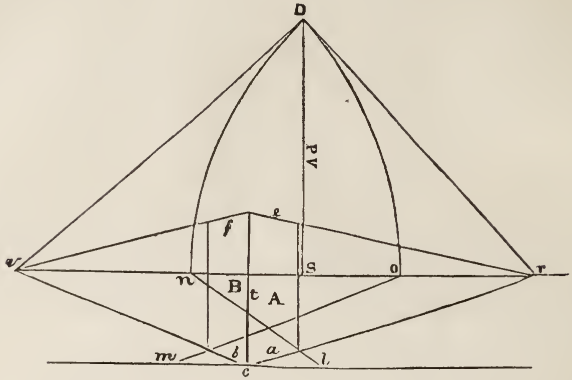


Fig. 16.

It will be seen that this method of finding *one* point on a vanishing line is that of finding any point required, by varying the measurement on the ground line, and therefore that it covers the whole ground of perspective distances.

No more need be said in explanation of the principles of perspective, since in every problem only two things are to be regarded—one, the right direction of vanishing lines, the other, the finding of points on those lines, which are to be connected by straight or curved lines according to the form to be delineated.

LINEAR PERSPECTIVE.

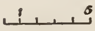
PART II.

In the application of the foregoing principles difficulties will doubtless arise requiring further elucidation by means of practical examples. If the student will copy with neatness and accuracy the following diagrams, he will be amply repaid for whatever attention he may bestow upon them.

THE USE OF A SCALE.

Ordinarily, in sketching from nature, the eye alone may be trusted to determine the relative proportions of objects and their parts. But where greater accuracy is required, the draughtsman must resort to a scale, which may be of any number of inches, or parts of an inch to a foot. Fig 17, for example, is a scale of five feet. This scale must be set off on the ground line, and adapted to any distance on the ground plane by perspective diminution, *i. e.*, by ruling from its extremities to some point in the horizon.

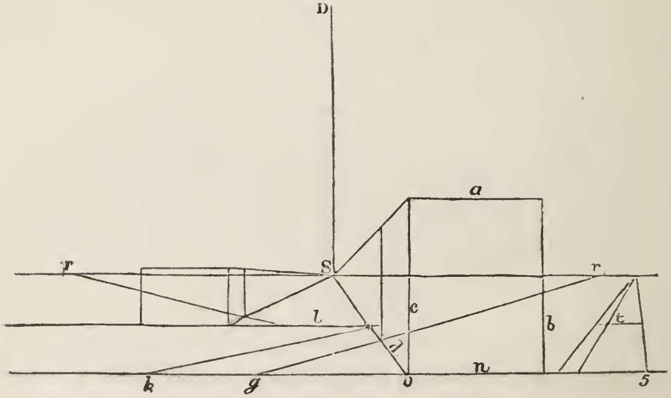
Fig. 17.



A good illustration of the scale and its use, is found in a railroad track, whose rails, if extended on level ground, vanish in the horizon. The track, though uniform in width, grows apparently narrower as it recedes. Suppose the rails to be five feet apart, and two poles to be erected on the track each ten feet high, one at its junction with the ground line, the other half a mile away. It is evident that the apparent width of the track on the ground line must be taken as the standard or *scale* for determining the height of the nearest pole, and its apparent width half a mile off, that of the more distant one, the same ratio of diminution affecting each.

In Figure 18 a scale of five inches, drawn perspectively, is applied to determine the dimensions of two blocks, one of which stands fifteen inches away from the picture plane.

Fig. 18.



By this scale the lines *a*, *n* are seven inches long, and *c*, *b* ten inches. From *o* to *g* is eight inches, and a line from *g* to the radial point *r*, by its intersection of the vanishing line *d*, gives the perspective width of that side of the block, eight inches. From *o* to *k* is fifteen inches, and a line from *k* to *r* intersects *d* perspectively at the same distance. Therefore the second block, standing on the line *l*, drawn horizontally from this intersection, is fifteen inches from the picture plane. If the line *l* is continued horizontally till it crosses the scale, it will give *t*, which is the scale adapted to all measurements at that distance. By this scale the block is ten inches long, six inches high and five inches wide. The latter is found by setting off five inches on the line *l*, using, of course, the diminished scale for that purpose, and ruling thence to the radial point *r*.

Figures 1 and 2, Plate 1.

POINTS UPON PLANES.

Figures 1 and 2, Plate 1, show the method of finding points on several planes, holding different relations to the picture plane. Particular attention is requested to these figures, as they embody the essential features of the system we are presenting.

Figure 1 contains two planes (the two sides of the room), parallel to the prime vertical plane, and two (the floor and ceiling) parallel to the horizon plane. The scale by which it is drawn is one-eighth of an inch to the foot, which is diminished perspectively by drawing to the horizon.

To find on the floor the point *a*, set off its distance from the ground line, which is seven feet, from *b* to *c*, and rule to *R*, which gives *d*. Then set off ten feet, its distance from the left-hand wall, from *b* to *o*, and rule to *S*. The intersection of this line with a horizontal line from *d* gives *a*. This point may be found more readily by setting off ten feet horizontally from *d* by the diminished scale, *f*, thus dispensing with the line from *o* to *S*.

The point *g*, on the ceiling, is found in the same way by ruling from *n* to *R*, and from *t* to *S*. Invert the diagram, and the methods will be seen to be identical. The point *h*, on the side of the room, is found by setting off its distance, five feet, from *i* to *k*, and ruling to *R*, and its height from *i* to *l*, five feet, and ruling to *S*. Its height may as well be set off directly from *m* to *h* by using the scale adapted to that distance. By the same process any required point upon these and all similar planes may be found.

Points upon oblique planes, as in Fig. 2, are obtained in like manner, with the difference that lines upon those planes vanish at other points than the point of sight, and consequently require other radial points; *a* on the side of the house, and *o* on the roof, are each three feet from the corner line; *o* being three feet distant in two directions. Set off this measurement on each side of *t*, and rule to the radial points *R*, *R*. (See the explanation of Fig. 14.) *c* and *h* on the base vanishing lines, are each three feet distant, as are also *e* and *g* at the roof, whence lines to their respective vanishing points give *o* at their intersection. The height of *a*, which is five feet, is set off from *c* by the diminished scale, *n*.*

Fig. 3, Plate 1.

INTERIOR, WITH OBJECTS.

In constructing this figure draw the horizon, and mark the point of sight, *S*. The radial point, *R*, is set off on each side of *S*, because there is occasion to use it on each side. See Fig. 13.

Points upon the floor, sides and ceiling for the legs of the table, corners of the windows, etc., are found as in Fig. 1, Plate 1. The height and front width of the various objects may be given at once by the scale adapted to the distance at which it is to be applied. Thus, the scale *a* may be used to determine the height and width of the nearest end of the table, because it is the perspective length of a foot at that distance from the picture plane. Receding or perspective widths must of course be determined according to Rule 2, as exemplified in Fig. 18.

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* As a school exercise it will be useful for the pupil to draw from blocks, whose surfaces may be placed in a variety of relations to the picture plane. He should be required to designate the vanishing and radial points, and to determine in his drawing the position of points which the teacher may mark upon the blocks. Great care must be used not to confound the vanishing with the radial points. The latter are never vanishing points, but their sole use is in finding points on vanishing lines.

Fig. 4, Plate 1.

VIEW OF A STREET.

Here is no change in the process, but the width of buildings and all points on their sides, for the corners of windows, etc., are found as before directed. The height of a figure, or of any other object in the distance, is fixed by erecting a line *o* of the true height, by scale, or proportion, on the ground line and ruling from its extremities to the vanishing point. This, as may be seen, is only an adaptation of the scale.

The sloping lines of the shade are parallel to the picture plane, and do not vanish, but are expressed by parallel lines at the proper angle from the building to the posts.

Fig. 1, Plate 2.

STREET IN OBLIQUE PERSPECTIVE.

As there are two vanishing points, there are also two radial points (Fig. 14), neither of which in the present instance is within the limits of the picture, but may be obtained by the student on a larger sheet. For the width of the buildings and points upon their sides for the places of windows, doors, etc., consult Fig. 2, Plate 1. The height of figures and other objects is determined as in Fig. 4, Plate 1. The sign, *o*, and all projections at right angles with the side of the buildings vanish with the side *A*, being in a parallel plane. Figures crossing the street at right angles move in the same direction.

Fig. 2, Plate 2.

TABLE IN PARALLEL PERSPECTIVE.

The length of the table is found on the vanishing line *o* by setting it off on *A* from *c* to *p*, and ruling to *R*. So, also, the distance of the pitcher, and any other required point on the top of the table. Since the distance of *A* from the picture plane is no greater than that of *g*, the result is the same whether we find the length of the table by measurements on *A* for the line *o*, or on *g* for the line *d*.

Figs. 3 and 4, Plate 2.

ELEVATED POINTS.

In determining elevated points it is sometimes necessary to find corresponding points on some horizontal plane below them.

In Fig. 3 the points *t*, *t* for the angles of the roof are first found on the floor at *o*, *o*, and the apex of the pyramid, Fig. 4, is directly over the perspective centre of the base, which is found by the intersection of diagonal lines from its corners.

Fig. 1, Plate 3.

STEPS IN PARALLEL PERSPECTIVE.

Draw the elevation, *A*, of the first step, set off its width on the ground line, from *b* to *l*, and rule to *R*, giving *b o* for its perspective width. Rule from *a* and *b* to *S*. *o u* is the height of the first step at the distance *o*, and by repeating the distance from *u* to *n* the height of the second step. A repetition of this process will give the height and width of each succeeding step. But an easier way after obtaining *u n*, is to draw a line from *a* through *n* to the prime vertical line, and from *b* through *u* to the same point. These lines will define the inner and outer angles of the steps for the entire flight. From *a* and *n* draw to *S*, which is the vanishing point of all the horizontal vanishing lines.

Figure 2, Plate 3, shows the application of the above to steps in oblique perspective.

The dotted lines, which define the angles, do not vanish in the prime vertical line, but in a line vertical to the vanishing point of the plane to which they belong. (See *o*, *p*, Fig. 7.) It will be seen that the width obtained by these lines coincides with that found by ruling from measurements on the ground line to the radial point.

Fig. 3, Plate 3.

This figure shows that a series of squares, like a tesselated pavement, may be constructed on one diagonal to *R*, by its intersection with equidistant vanishing lines.

Fig. 4, Plate 3.

PROJECTIONS TOWARD THE SPECTATOR.

It is sometimes required to project an object, as, for instance, the porch of a house, to a given distance toward the spectator.

Let *d*, Fig. 4, stand for the base line of a house, from which the line *i* is to be projected four and a half feet. Draw *g*, as a ground line, parallel to *d*, anywhere in advance of the required projection, and continue *i* till it cuts this ground line. On *d* set off the scale *o*, one foot, and draw lines touching its extremities from a point in the horizon to *G*. The scale is thus put in perspective, and *n* is the representative of a foot on *G*.

From the radial point *R* draw through *e* to the ground line, giving *a*, whence set off four and a half feet by scale to *h*. Rule from *h* to *R*, and where this line cuts *i* at *t* is the point required.

This process is simply the reverse of projecting a line in the opposite direction, from *t* to *e*, as shown in preceding figures.

Figs. 19 and 20.

CIRCLES IN PERSPECTIVE.

Circles may be put in perspective by enclosing them in rectilinear forms, so as to obtain points, as in Fig. 19 ; and by drawing these forms perspectively, the same points can be found to regulate the curve, as shown in Fig. 20.

Construct a circle of the diameter desired, and enclose and intersect it as in Fig. 19.

Fig. 19.

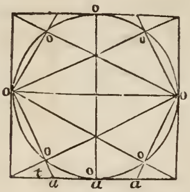
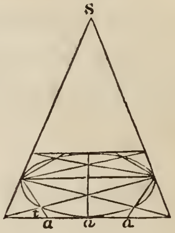


Fig. 20.



Make the line *t*, Fig. 20, equal to *t*, Fig. 19, and divide it into equal parts at *a*, *a*, *a*. The perspective centre of Fig. 20 is found by the intersection of lines drawn diagonally from its corners. Other lines explain themselves.

Draw by the eye, in Fig. 20, a curve through the same points, marked *o*, which are intersected by the circle in Fig. 19. The result will be a perspective view of a circle, which is always an ellipse.

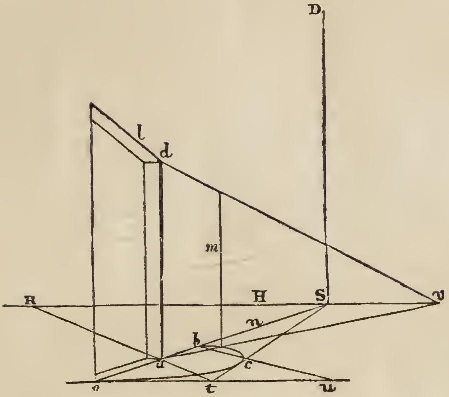
In ordinary cases circles may be drawn with sufficient accuracy by the eye, noticing that their appearance is more or less elliptical, according to their distance from the horizon plane if they are horizontal, and the vertical plane if vertical. The nearer they are to these planes the more elliptical they appear.

Fig. 21.

AN OPEN DOOR.

Draw the base line of the side of the room, *n*, Fig. 21, vanishing at *S*, and on it, at *o*, erect a line to the height of the door. Set off the width from *o* to *t*, and again from *t* to *u*, and rule thence to *R*. You thus get the point *a* for the perspective width of the door when closed, and *b* the point

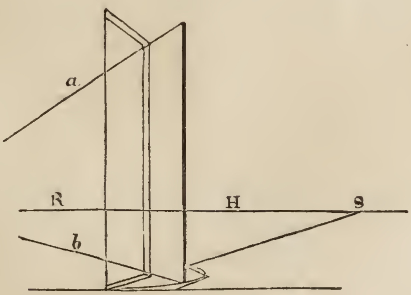
Fig. 21.



at which its corner would rest, were it thrown back against the wall. Draw the line *o* to *S*, also from *t* to *S*, and from *a* to *l*. The door opens on the semicircle, *o*, *c*, *b*, with *a* for its pivot; *c* being the point at which its corner would rest if it stood open at right angles with the wall.

The door may be opened at any angle at the option of the artist, and its vanishing point will be in the point of sight, or more or less remote from it, according to its relation to the picture plane. Thus, if it were thrown back against the wall, its top and base lines would vanish with the line *n* at

Fig. 22.



S; but in its present position they vanish to the right of *S*, at *v*. Rule to *v* from *d*, also from *a*, and from the intersection of the latter with the semicircle, connect these lines by *m* to complete the door.

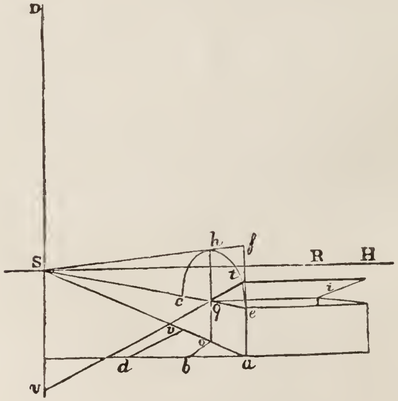
Figure 22 is drawn in the same manner as the last. It differs only in vanishing at another point in the horizon, because of opening at a different angle. *S* is the point of sight. *R* the radial point; *a* and *b* run to the vanishing point.

Fig. 23.

AN OPEN BOX.

This is drawn on the same principle as an open door. Set off its width from *a* to *b*, and again from *b* to *d*, and rule to *R*. You obtain *o* and *u*, from which to raise vertical lines, one for the width of the box, the other for the point *c*, at which the cover would fall if it were thrown horizontally back. The cover opens on the semicircle *e*, *h*, *c;* *h* being the point where it would rest if it stood upright. To find *h*, take the width of the box, *a*, *b*, and set it off from *e* to *f*,

Fig. 23.



and rule from *f* to *S*; *g*, *h* is the apparent width of the cover in that position. In another position its width will be the radius of the circle whose centre is *g*—the pivot on which the cover turns in opening. Open the cover at pleasure, and find its vanishing points according to the directions given for roofs in Figs. 6 and 7; *i. e.*, on a line vertical to the vanishing point of the plane or side to which its lines belong. In the present case the cover opens to *t*. Draw from *t* through *g* to the prime vertical line, giving *v* as the vanishing point, to which also *i* is to be drawn. If the cover were thrown partially back, its vanishing point would be in the prime vertical, above the horizon. If horizontally back, it would vanish in the horizon.

CURVILINEAR FORMS.

In all curvilinear forms the eye must to a great degree be relied on for their accurate delineation. No artist, for instance, in drawing the human form, thinks of applying rigidly the rules of perspective. His eye alone, governed indeed by science, enables him to define with sufficient accuracy each limb and feature, giving them their due space upon the canvas. If the rules are definitely applied, it is only for the purpose of securing a few leading points and proportions.

While the principles of perspective must be well understood, and ever in his mind, he will in this and similar cases rely for the most part upon his eye and judgment for their application.

The method already given of enclosing circular forms in rectilinear figures, and putting those figures in perspective, and then drawing the required form within the figure, is the best that can be used, and within its limits as many guiding points as are needed may be obtained.

SKETCHING FROM NATURE.

In sketching from nature begin leisurely by selecting the most attractive point of view. Determine how much of the scene to include, and the scale or size to which to reduce it. Draw *lightly* the horizon and prime vertical lines, as standards, in relation to which all the lines of the scene are to be arranged. To obtain starting points for one or more of the principal objects, adopt the following method: Hold the paper upright before you, at such a distance as that it will just cover as wide an extent of the landscape as you intend to sketch. Select some prominent point as, for instance, the roof of a house. Its distance to the right or left of the prime vertical line may be found by so holding the paper that this line coincides with the imaginary prime vertical plane. Then lower the paper (still keeping it upright and at the proper distance from the eye) until over its upper edge may be seen the point whose place you wish to fix. There make a dot just on the edge of the paper. Then raise the paper to its former position, *i. e.*, till the horizon line upon it coincides with the horizon plane. Move it carefully to the right or left, until the point of the roof is again seen on the edge of the paper, at its side. There, also, make a dot which will determine its place above or below the horizon plane. A horizontal and a vertical line from these points will intersect at the point required. Artists in this way sometimes obtain several leading points, and thus facilitate the process of sketching, and perhaps ensure a truer relation of parts than would result from reliance on the eye alone.

Having thus obtained a few starting points, it will be found that the process of outlining the various features of the landscape, with all the minutiæ of detail that can be put in only by the eye, will afford ample scope for the exercise of that organ, both testing and strengthening its capacity of observation, till eventually all mechanical contrivances may be discarded.

If there are no artificial structures in view, there is little opportunity for the *formal* application of the rules of perspective; yet even the most undulating lines of the landscape must be considered in relation to the planes to which they are proximately parallel, for their representation is affected by such relation. This may be seen in hills and mountain ranges receding from the picture plane, in the cliffs of coast scenery with their broken and varied outlines, and in the boundary lines of lakes and rivers. Notice, in respect to the latter, that under the law regulating the appearance of circular forms, their near and distant borders, though wide apart, may seem quite close together. Beginners are liable to allow their knowledge of the actual dimensions to affect their drawing, causing them to give too much space to a sheet of water or a wide extent of level land.

If buildings are included, begin with some prominent line, as, for instance, the line *o*, Plate 6, and having found the vanishing and radial points, and established the principal dimensions, the smaller parts, such as windows, doors, chimneys, etc., may be put in by the eye, after the rules for drawing them are well understood.

When the main building is correctly sketched, it becomes a guide for the dimensions of objects that adjoin or are secondary to it. Thus, in the plate just referred to, it may be observed that by holding the pencil horizontally, a little lower than the eaves of the house, it will cut the peak of the roof of the nearest barn, which also, when completed, indicates the drawing of the barn beyond it and the height of the adjacent trees.

If it is not convenient to draw with precision on the spot, as may occur where vanishing points are not within the bounds of the paper, do it as near as possible, and find by the card, Fig. 10, the parallels of the original vanishing lines, and note on their representatives the number of degrees to the right or left of the prime vertical plane at which they vanish. Other minutes of size and proportion, the number and position of windows, doors, etc., may be made, and at home, under more favorable circumstances, you can copy and complete the sketch.

Many of the lines which have thus far been used for illustration may be dispensed with in practice, by merely placing a ruler in the right direction and marking points where they are wanted.

In the succeeding plates it has not been thought advisable to introduce the method by which the perspective widths were found, because by this time it must be familiar to the student, and its presence would only confuse the drawing by a multiplicity of lines.

The point of distance, and in some cases the vanishing points, cannot be given, because they are not within the bounds of the paper. The horizon line is designated by *H*, the point of sight by *S*, and all lines which vanish at one and the same point are marked by the same letter, as *a*, *a*, *a*, Plate 4. Dotted lines indicate the way of working.

PLATE 4.

This plate hardly requires explanation. The lines *a*, *a*, *a* vanish in *H* on one side of the prime vertical plane, and *b*, *b* on the other. Their vanishing points will appear by continuing these lines on a larger sheet of paper. At *S* erect the prime vertical line and find on it the point of distance, which will be where lines from the vanishing points cut each other at right angles, as explained under Fig. 9. This point being determined, the radial points are easily found, as in Fig. 14. The lines *o*, *o* of the roof vanish in a line vertical to the vanishing point on the right, and *n*, *n* in a similar line on the left of the prime vertical.

The above method of finding the vanishing points, and thence the point of distance and radial points, is given only to show the pupil how to test the accuracy of a drawing when these points are not expressed. In his own drawings he will of course proceed as before directed.

PLATE 5.

In this plate *S* is the vanishing point for the horizontal vanishing lines. Those of the inclined planes, from the water to the doors, vanish in the *P. V.* above S. The front lines of the roofs are parallel to the picture plane and do not vanish. Outlines of hills, trees, etc., must be drawn by the eye. First draw the buildings in their place, and then sketch the surrounding landscape. This is always done when buildings are the principal objects of the picture, but where they are subsidiary it is not required.

PLATE 6.

We have already remarked on this plate (page 33), and it needs no further explanation. It is, as will be seen, in oblique perspective.

PLATE 7.

Plate 7 is from an elevated point of view. The vanishing point of the horizontal lines is *S*, but the road, which is up hill, vanishes above the horizon at *v*. The horizon line always indicates the height of the eye, and therefore, as will be seen in the present instance, coincides with the natural horizon, *i. e.*, where the sky and water meet.

PLATE 8.

The buildings in this plate stand in various relations to the picture plane. Some vanish in the prime vertical, others to the right and left of it. In each case the ascending lines of the roof, if continued, will be found to vanish in a line vertical to the vanishing point of the horizontal lines of the building to which they pertain.

The questions appended to this treatise extend to the 23d page. When the student is able to answer them, he may continue his lessons by copying from time to time the following figures, drawing the lines in their proper order, by which means only he can do it understandingly. He should then be diligent in the application of the rules and principles to objects around him until he can draw them with facility. To this end he will need no further instruction, even for the most difficult problems, but only that degree of skill in execution which results from practice.

QUESTIONS.

ANSWERED ON PAGES 5, 6 AND 7.

Those in italics are not answered in the text.

What is Perspective? How may it be illustrated? What may we conclude from this illustration? *What is meant by the term* PARALLEL? What familiar illustration can you give of perspective appearances? *Define the term* VERTICAL. What must we know in order to make a correct perspective drawing? *What is meant by the term* PLANE? What is the Picture Plane? What is the Ground Plane? What is the Ground Line? What is the Horizon Plane, and how may it be represented? What does the Horizon Line represent? How is it related to the Ground Plane? What is the Vertical Plane? How may it be represented? How expressed on paper? *What is a right angle?* What is the line called which represents the Vertical Plane? What is the Central Visual Ray? With what does it coincide? How is it represented on the Picture Plane? What is the Point of Sight, and its position on the Picture Plane? What does the Point of Distance represent? Where and how is this distance to be set off?

The teacher may here represent the above-named planes, as shown in Fig. 2, by sheets of metal or stiff paper, and require the pupil to draw and name the lines, Fig. 3.

What does D, Fig. 3, represent? Where and how may it be set off?

Pages 8 and 9.

How is the Picture Plane to be prepared for drawing? How is the Horizon Line affected by the position of the artist? How is it usually placed? What is the position of the Prime Vertical Line? *How many degrees are there to a circle?* How many can the artist take in at a view—*i. e.*, without turning his head? Explain the mode of placing the vertical line according to the portion of the view to be included in the sketch. How should the artist stand in relation to the scene he is to draw? Explain his position by the Circle. If he draws at an angle of 30 degrees, how far will he be from his scene? How is this principle to be applied? How will the distance be affected by drawing at an angle larger or smaller than 30 degrees? On what line is this distance to be expressed, and how?

Pages 10 and 11.

How can the position of the artist, in respect to his point of distance, be made plainer? Explain the original ground line and the relation thereto of the original picture plane? What are the representatives of this original line and plane? How is the drawing affected by the relation of the representative line and plane to their originals? If the original ground line were 50 feet long, how far would the artist stand from it in sketching if he drew at an angle of 30 degrees? *Answer.* Twice its length, or 100 feet. How far if at an angle of 60 degrees? *Ans.* Once its length, or 50 feet. Draw and explain Fig. 5. What planes do not vanish? How are the dimensions and directions of such planes affected by the laws of Perspective? What planes vanish in the horizon? What planes vanish in the prime vertical plane? Give instances of these vanishing planes. Of what may we suppose all planes to be composed? How will those lines vanish? Give an example. When do lines vanish at the point of sight? Why do they so vanish?

Pages 12, 13 and 14.

What is the rule for determining vanishing points? How many distinct relations can a line hold to the picture plane? What are they?

(The teacher may explain this by the use of a straight rod, held in the designated positions, and requiring the pupil to tell how in each case the rod would vanish.) Draw Figures 6 and 7, giving a reason for every line. Let these figures be copied and studied until thoroughly understood and fixed in the memory, with their explanation as given in the text.

PAGES 15 AND 16.

Demonstrate by means of a frame and glass, Fig. 8, the truth of Rule I. What is represented by the vanishing point on the picture plane? *What is the meaning of the term* OBLIQUE? Illustrate, by means of a perspective frame (Fig. 9) and of the card (Fig. 10), the *exact* method of determining the vanishing points of oblique lines. When is it necessary to find by the card the vanishing point for only one side of an object which stands obliquely to the picture plane? Suppose one side vanishes at 30 degrees to the left of the prime vertical plane, how many degrees to the right will the other side vanish? If at 20 to the left, then how many to the right? *Ans.* 70. Why?

PAGES 17 AND 18.

Explain by means of the perspective frame, Fig. 11, the mode of determining perspective distances. A frame with threads and without glass must here be used. On what line must the points, *t*, *t* be represented? Why? The pupil may reduce Fig. 11 to a flat surface, as in Fig. 12, and explain it. What is the radial point? How is it obtained? Draw Figures 13 and 14 for illustration. How may the radial point be placed in parallel perspective? Are there more radial points than one in oblique perspective? Why?

PAGES 19 AND 20.

Has each vanishing line its own radial point? How is it to be used? Repeat the rule for determining perspective distances. Draw Figures 15 and 16 to show its application. What two things are principally to be regarded in every perspective problem?

Pages 21 and 22.

Construct a scale. On what line is it to be set? How is it to be diminished perspectively? What illustration can you give of a scale and its use? Copy Fig. 18, using the scale for determining its dimensions.

Plate 1

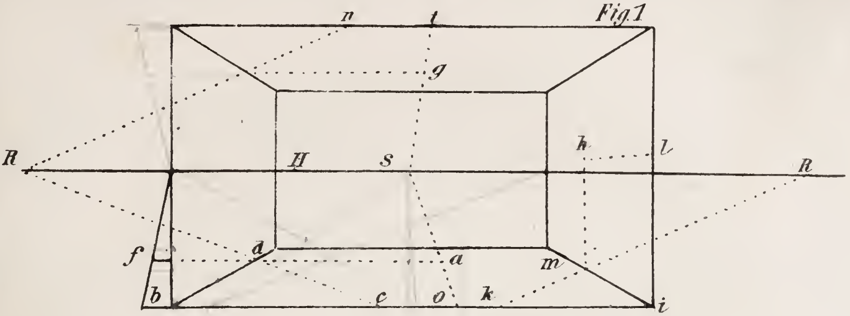


Fig.1

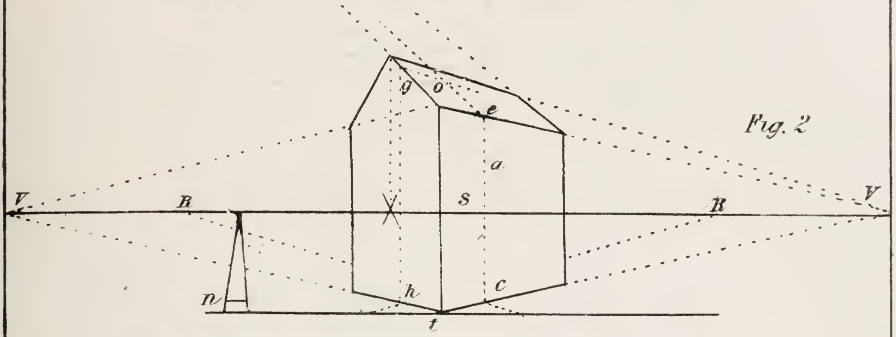


Fig. 2

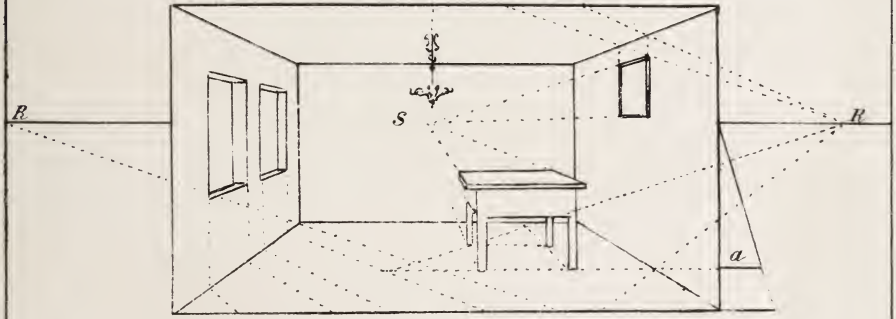


Fig.3

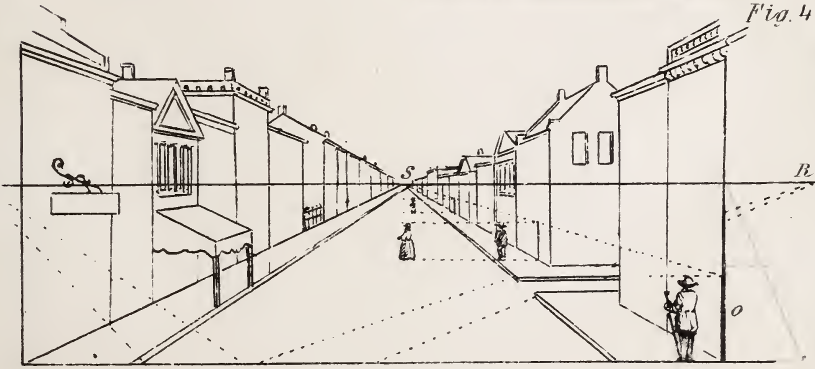


Fig. 4

Plate 2

Fig. 1

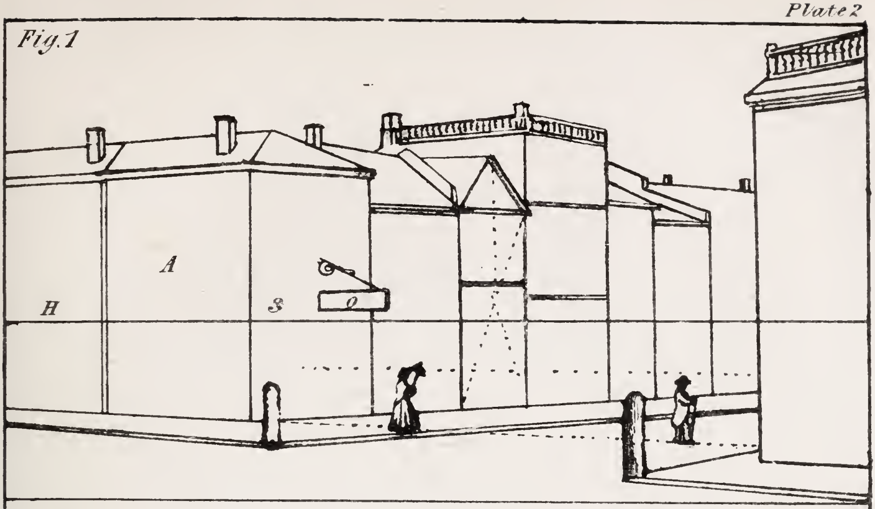


Fig. 2

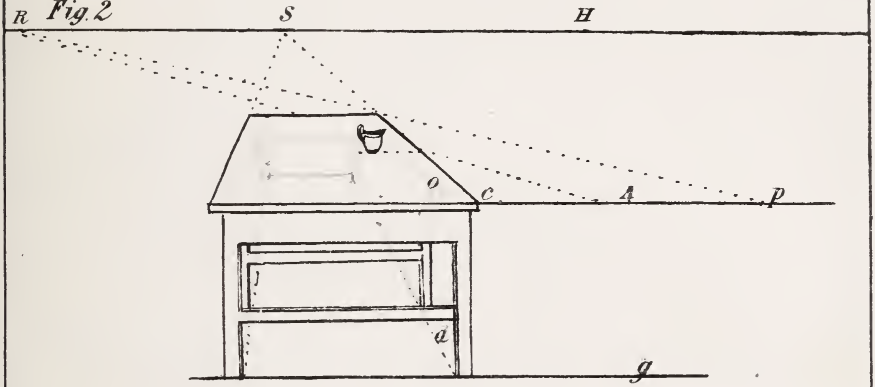


Fig. 3

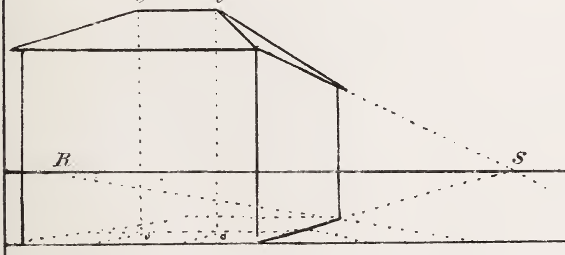


Fig. 4.

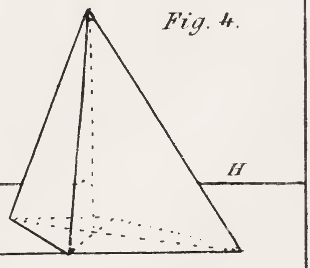


Plate 3

Fig. 1

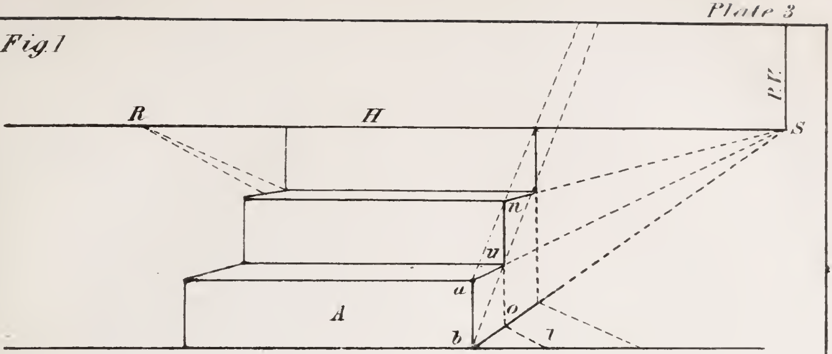


Fig. 2

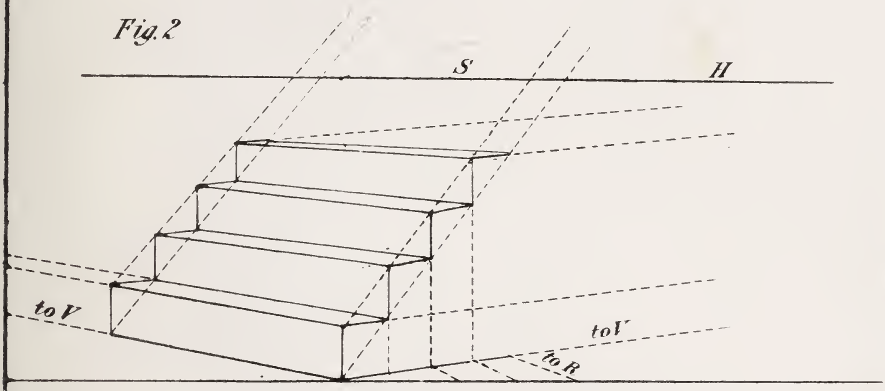
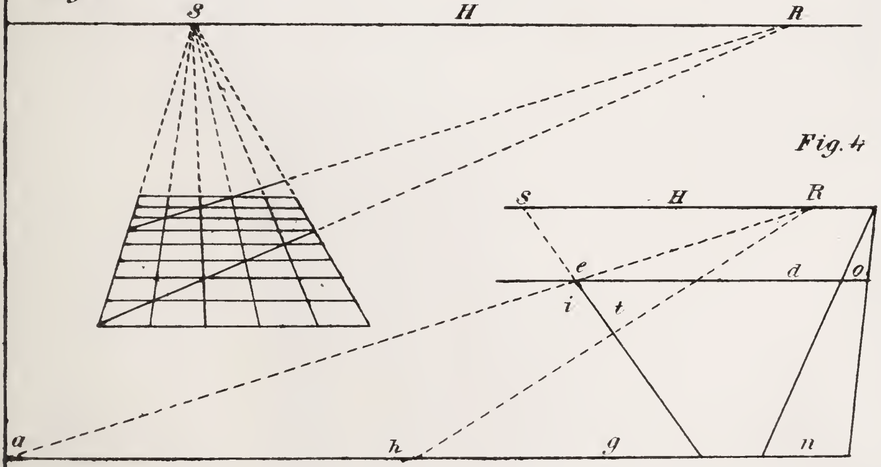


Fig. 3

Fig. 4



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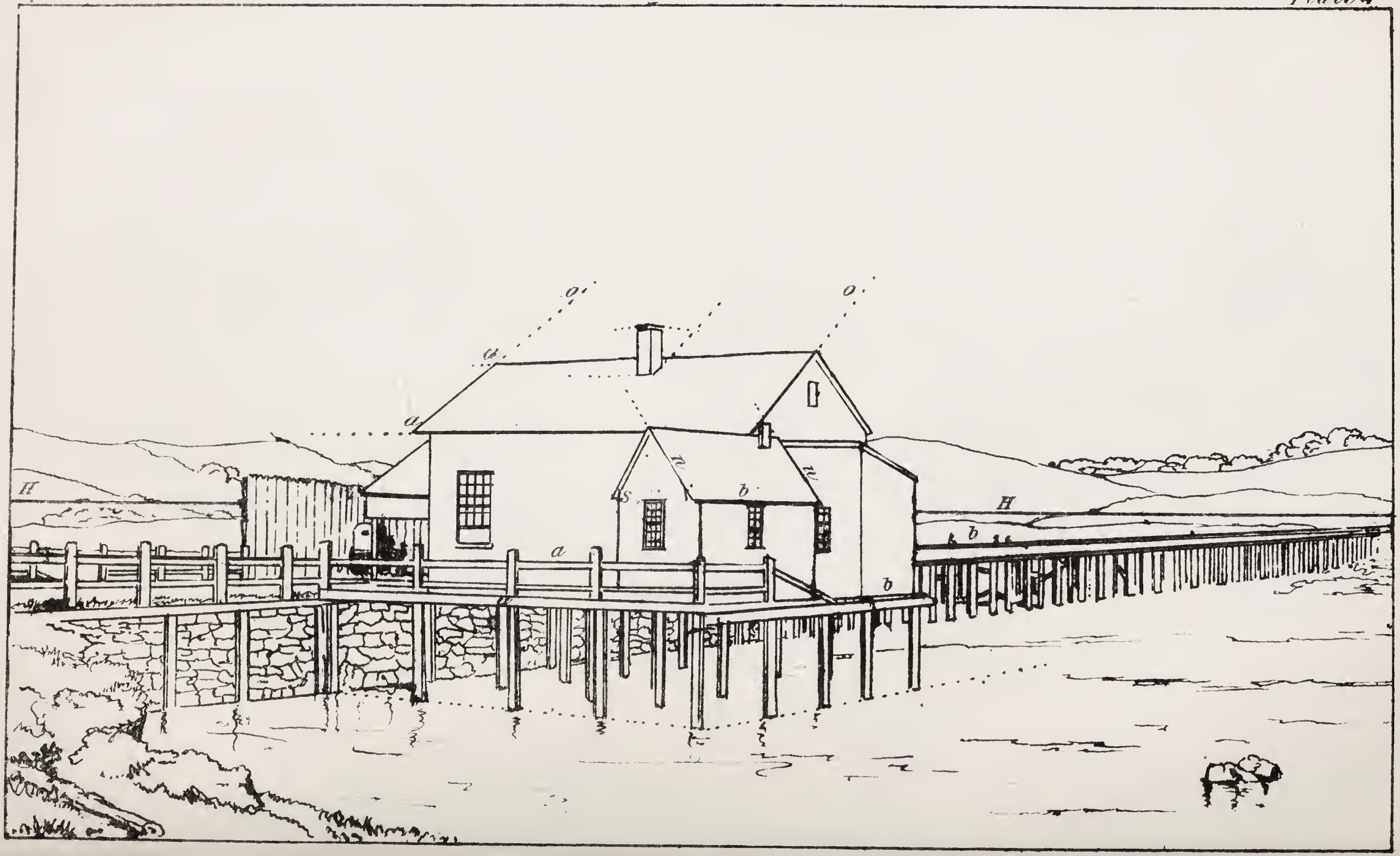

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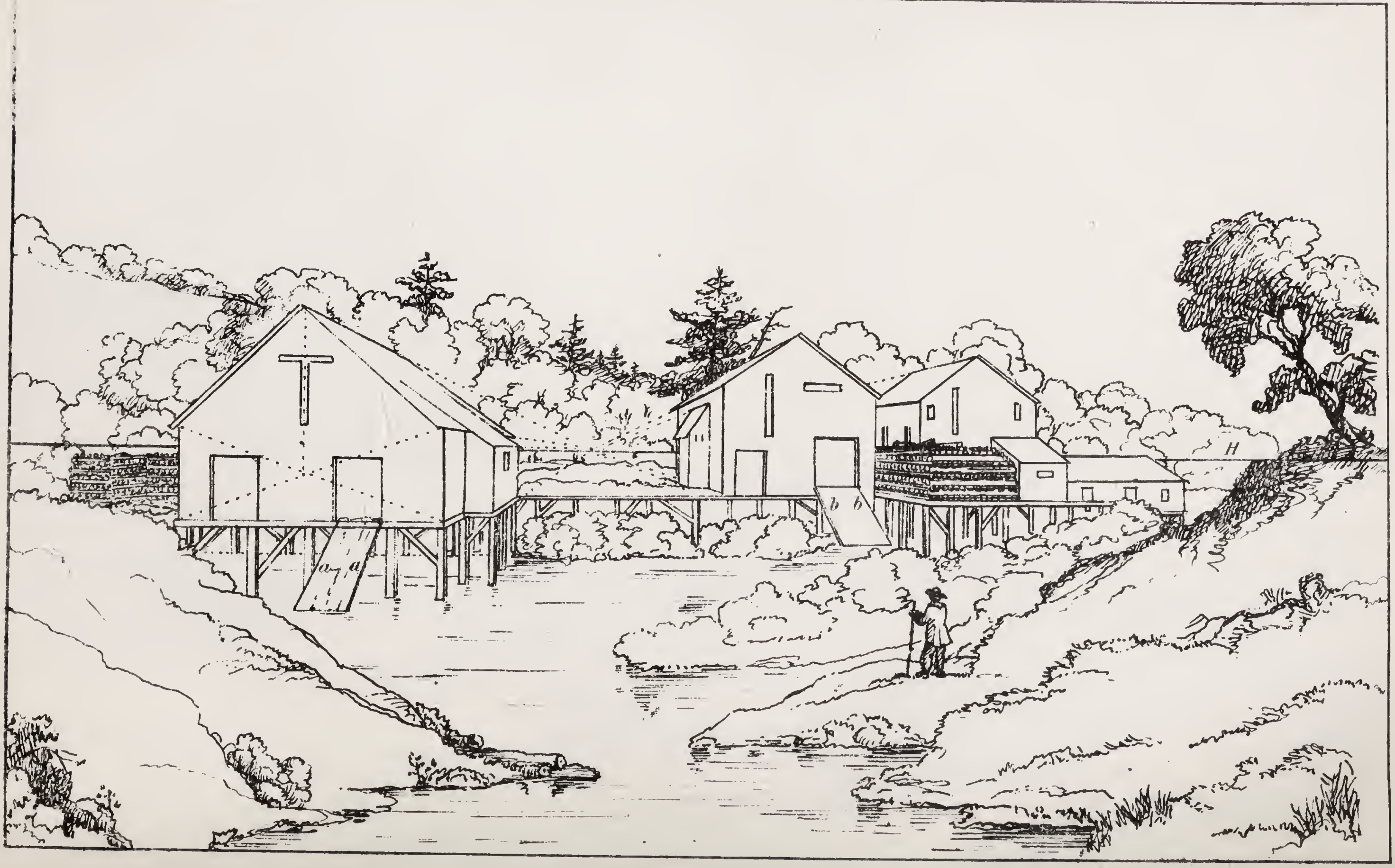

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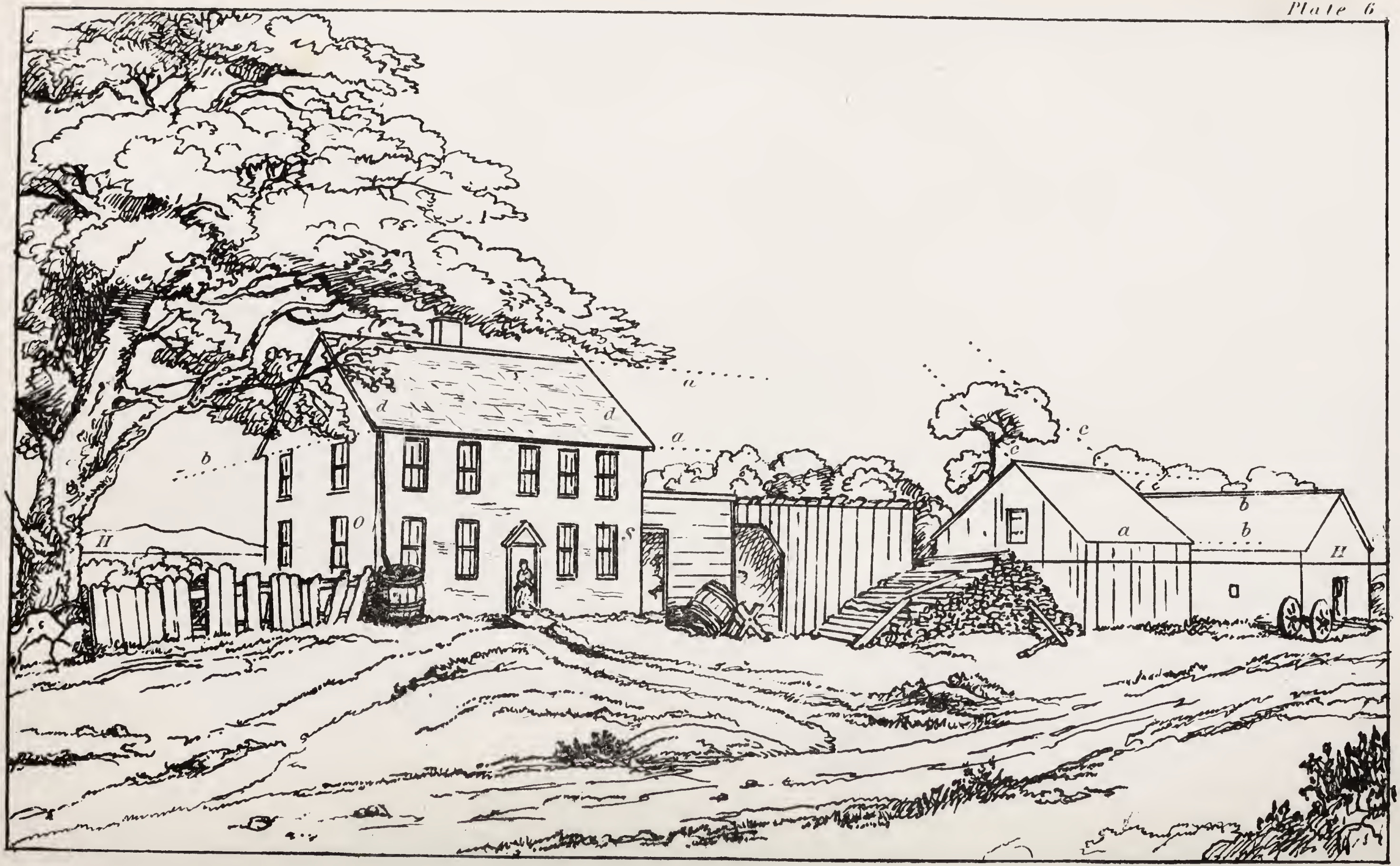
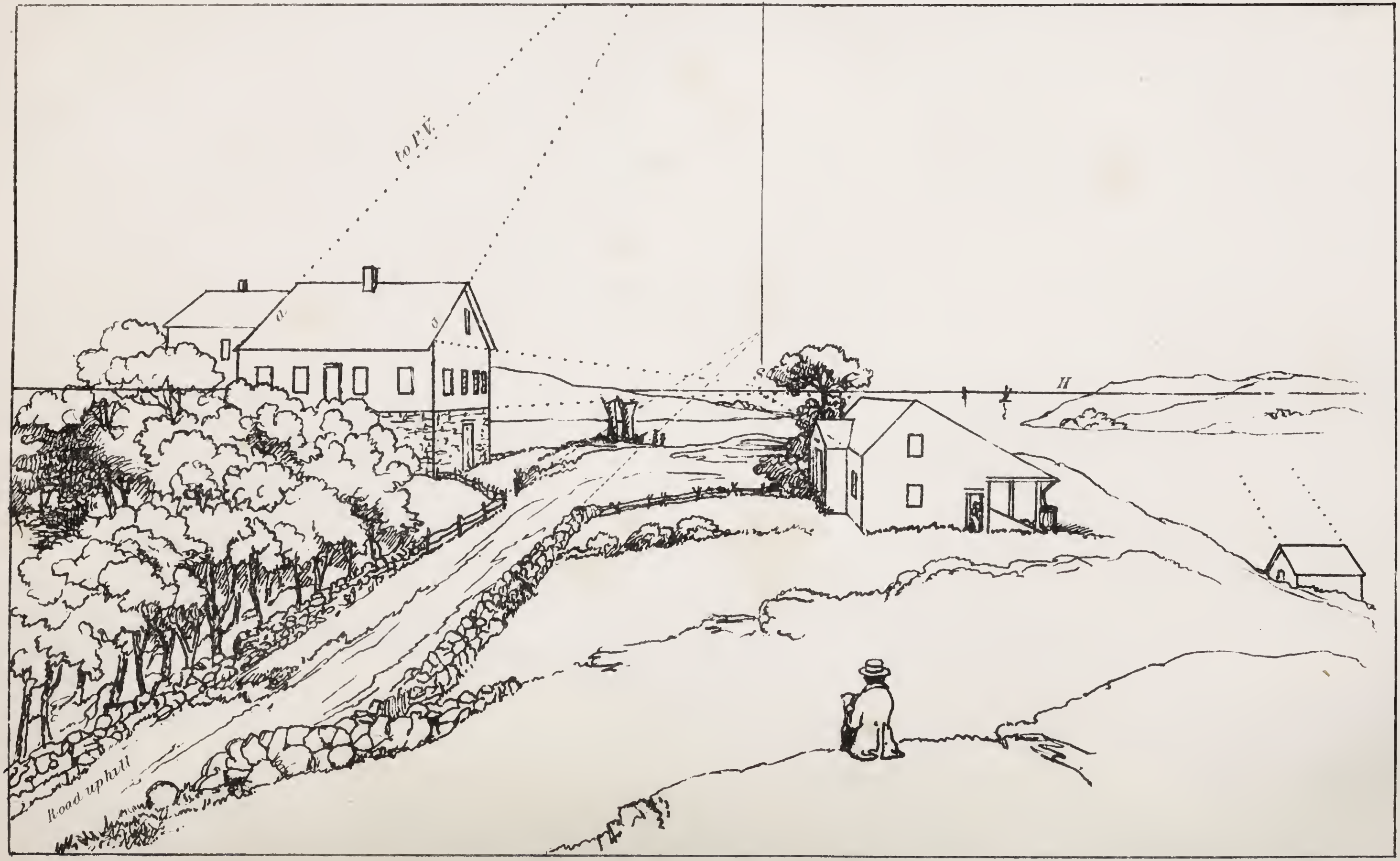


Plate 7



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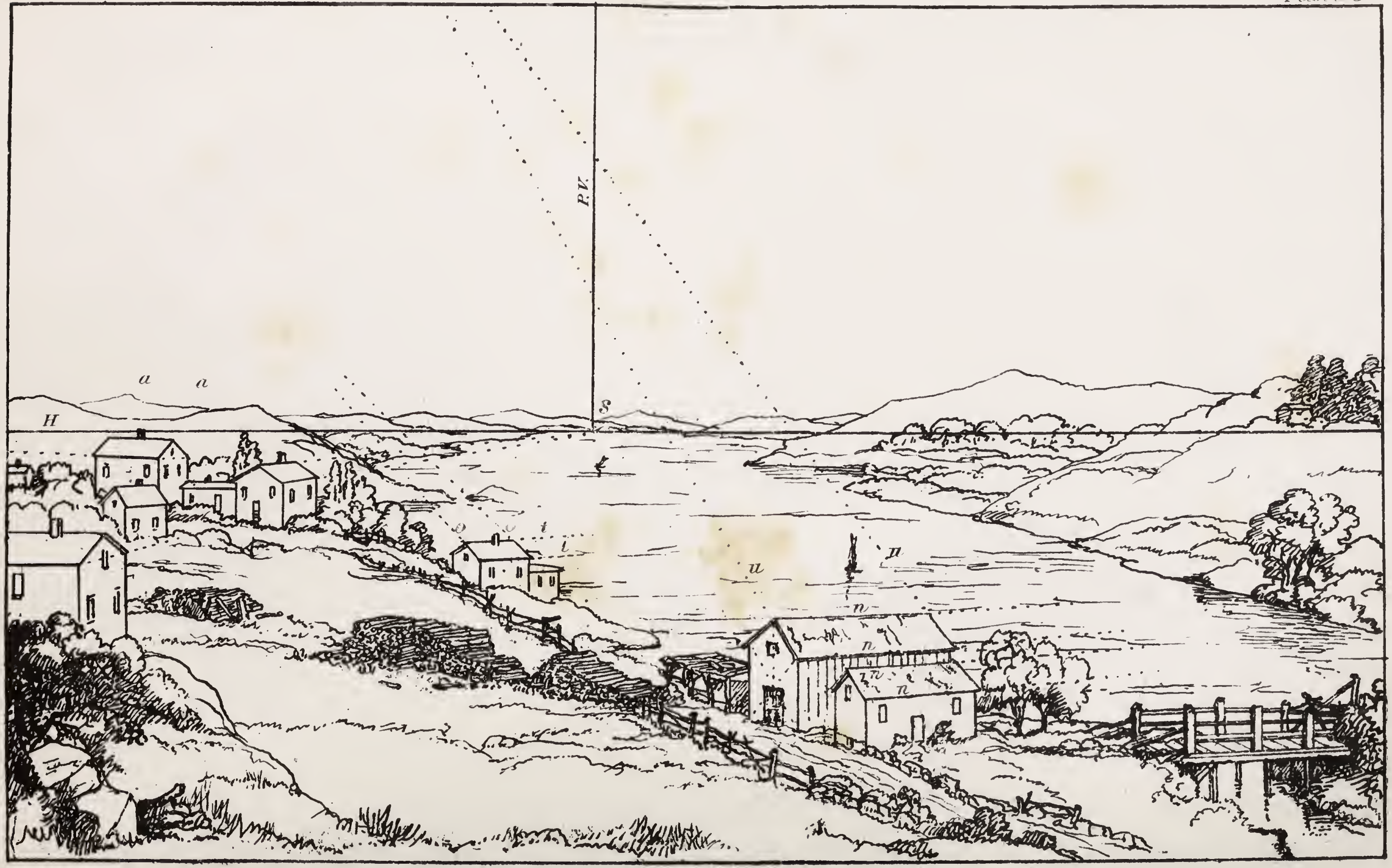

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